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(54) **Air traffic control system**

(57) An air traffic control system 15 (Fig. 2) for a region of airspace defined by surveillance radar system 17 and a plurality of reporting waypoints formed by radio beacons 18, includes a CRT display 30 (Fig. 3) and a display pointing input device, such as a joystick and cursor, whereby displayed flight progress data 35–40 can be accessed and then amended with the aid of a displayed menu 51. The flight progress data for each aircraft has a subset formed comprising its identification, cleared flight level, next reporting waypoint and estimated time thereto. Primary sorting means (33_1) assigns the subsets for aircraft whose next reporting waypoints is in the controller's region but not yet accepted by him to a pending group displayed at 40 and upon aircraft acceptance secondary sorting means (33_2) assigns the aircraft to groups, displayed at 35–39, according to next reporting waypoint. The use of subsets enables minimal information on many aircraft to be displayed in a small screen area for scanning by the controller and the screen area occupied by each subset provides a menu-like means of addressing the data for that aircraft. The full flight progress data for any aircraft so addressed is also displayed at 46. Screen space saved through the use of subsets may contain a synthetic radar map showing waypoints 12_1 etc. and aircraft 56 and the display pointing device can address the data of any aircraft by pointing to its map position as well as its subset position.

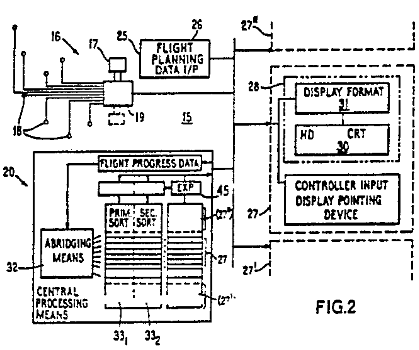

FIG.2

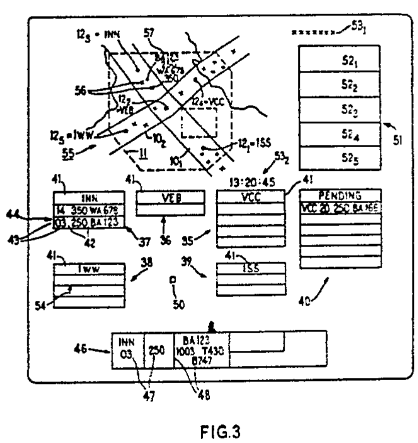

FIG.3

At least one drawing originally filed was informal and the print reproduced here is taken from a later filed formal copy.

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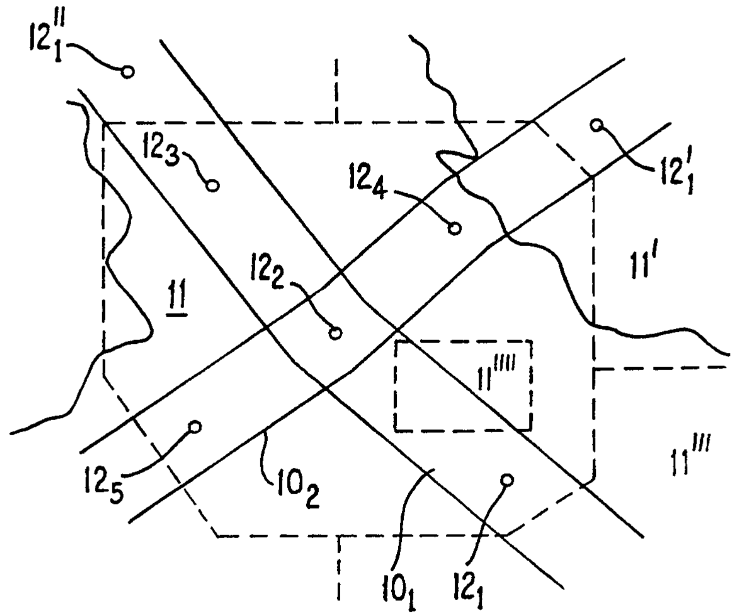

12''1
12'1
12_3
12_4
11'
12_2
11
11''''
12_5
10_2
11'''
10_1
12_1

FIG.1

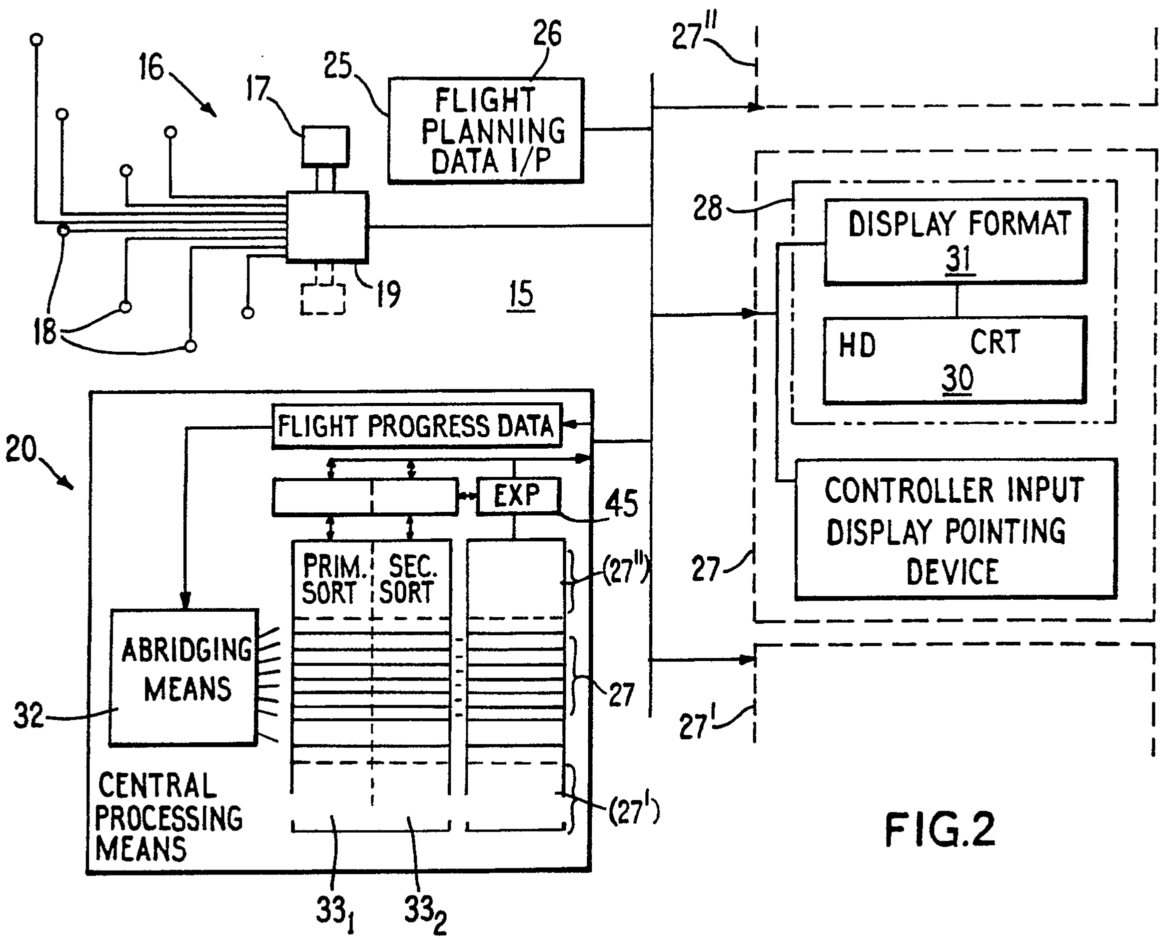
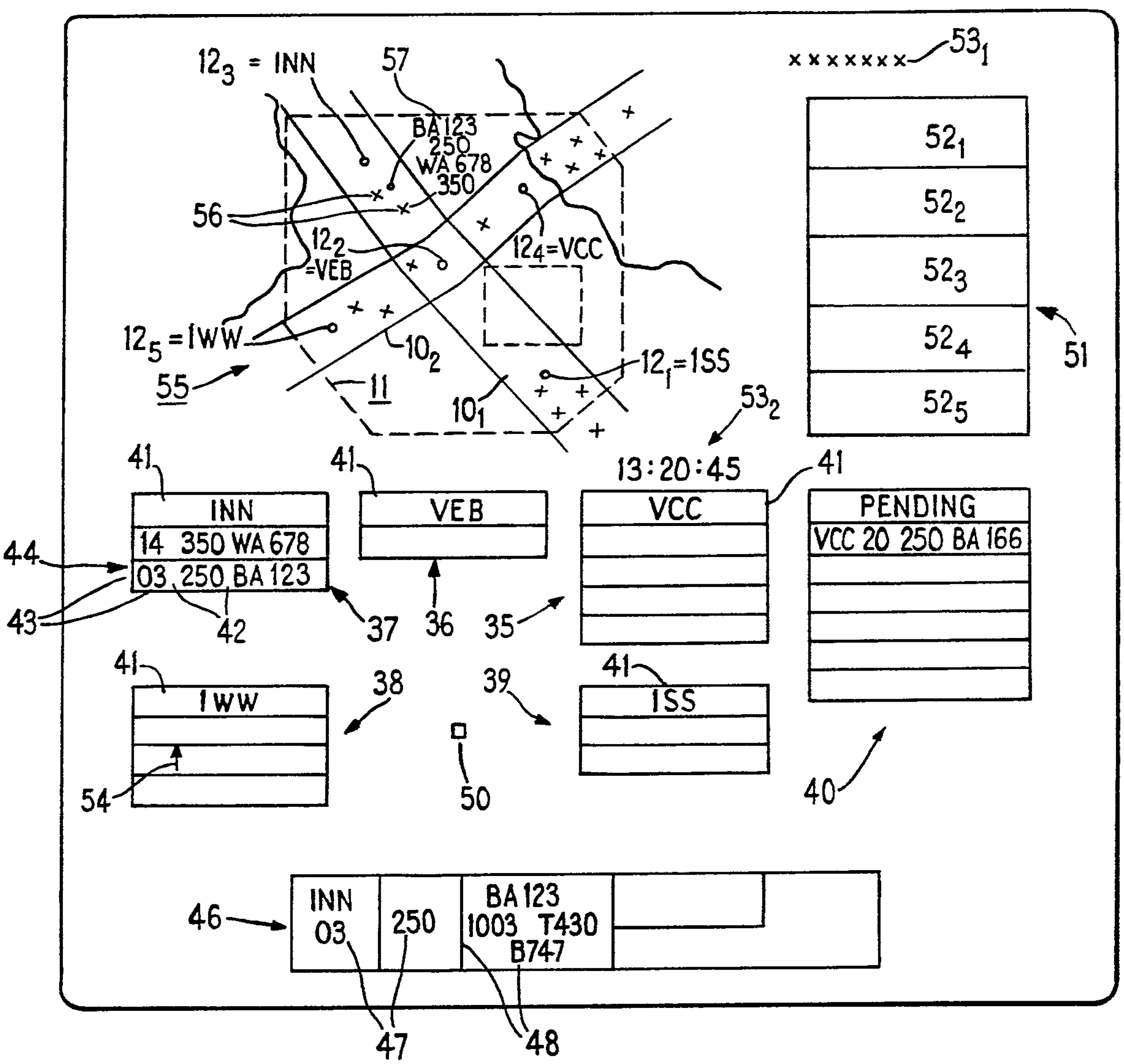

26
27''
16
17
25
FLIGHT PLANNING DATA I/P
28
DISPLAY FORMAT 31
19
15
HD CRT 30
18
20
FLIGHT PROGRESS DATA
EXP
45
CONTROLLER INPUT DISPLAY POINTING DEVICE
PRIM. SORT
SEC. SORT
(27'')
27
ABRIDGING MEANS
27
32
27'
CENTRAL PROCESSING MEANS
(27')
33_1
33_2

FIG.2



12₃ = INN
57
BA123
250
WA678
350
56
12₂
=VEB
12₄=VCC
12₅ =1WW
10₂
12₁=1SS
55
11
10₁
×××××××
53₁
52₁
52₂
52₃
52₄
52₅
51
53₂
13:20:45
41
INN
14 350 WA678
03 250 BA123
44
43
42
37
VEB
36
VCC
35
PENDING
VCC 20 250 BA166
1WW
38
39
1SS
54
50
40
46
INN
03
250
BA123
1003 T430
B747
47
48

FIG.3

AIR TRAFFIC CONTROL SYSTEM

This invention relates to air traffic control systems and in particular to interactive systems in which flight progress data displayed to a controller is modifiable by the controller and the modified data is entered into the system.

Air traffic control systems have by tradition divided the controlled airspace of the system into regions served by individual control stations at each of which a controller is in voice contact with an aircraft in, or about to enter, the region and issues instructions to the aircraft on a variety of flight parameters based upon voice information received from the aircraft pilot, printed flight plans, the position of the aircraft relative to others discernible from primary and secondary surveillance radar displays and, to a large extent, from comparison between the printed flight plan information of all the aircraft under the control of the station.

The printed flight plan produced before aircraft take off serves as initial flight progress data as it traverses the control system airspace and upon any change in flight parameters, caused by a conflict with other aircraft or upon request of the aircraft or controller, this printed flight progress data is annotated by the controller who then has to pass verbally to the next control station as the aircraft progresses the changes that are required to change that controller's printed flight plan data into current flight progress data. Such manual annotation requires actions on the part of the controller in excess of the maintenance of safe separation between aircraft in the region of the control station.

The printed flight plan information takes the form of so-called flight progress strips which have by usage over a number of years evolved into a standard format that presents a concise resumé of all planned flight data input to the system prior to take off of the aircraft including, in addition to the aircraft identification codes, cleared flight level through the region, reporting waypoints with an estimate of time to reach from the preceding way point and miscellaneous data which may,

for example, signify flying a non-standard heading, that is not along an air corridor between reporting waypoints, or any other data relating to the aircraft itself.

It has long been recognised that the use of such pre-printed flight progress strips is limiting due to the fact that changes made thereto in operation and indicative of updated flight progress data are not available to other controllers other than by the above mentioned verbal communication, that is, the only common database available to other controllers, particularly ones associated with adjacent regions to or from which control of a particular aircraft is handed by a pilot reporting procedure, is the initial planned progress.

Furthermore such flight strips have to be handled physically to dispose them in a convenient stacked order for dealing with them in turn and manually annotating them, the making of annotations to such stacked strips is ergonomically unsound and storage of the strips for some time after use, in case of enquiry into control instructions given and annotations made, causes additional problems.

Attempts have been made to automate the control operation to a greater or lesser extent. For example the Applicant's specification No. 2200820A describes presenting the flight progress strips simulated by computer generated images on a display screen, such as a CRT, from flight plan data stored in a central computer and by means of a display pointing device, such as a stylus, permitting annotation of the flight progress data on the displayed strips by input to the computer of amended flight progress data which is not only reproduced as an amended display but it is also available for all control stations deriving displayed flight progress data from that central processor, simplifying hand-off between controllers. Such a system is thus interactive in that data entered by a controller in relation to the flight progress data of any aircraft under his control alters the flight progress data in the system for that aircraft and available to other controllers in the system.

Furthermore by employing a central store and processor of flight progress data and electronic display techniques the

displayed, and possibly amended, flight progress strips can be moved about and reorganised in a manner similar to, but with greater ease than physical strips.

It is also known to produce a radar map showing the position of aircraft in the controller's region in relation to each other and in relation to navigational radio beacons which provide the reporting waypoints.

Such a radar map may be a synthetically generated display in which the points marking aircraft positions are tagged with alphanumeric data identifying certain features of the aircraft, such as its call code and current height. By producing the map display on a suitable apparatus, such as a raster scan cathode ray tube having a display pointing device for inputting instructions, any aircraft, or rather the set of flight progress data associated with it, can be identified and addressed.

It has been perceived that efficient air traffic control for any such station involves preferably observation of both forms of information, that which is geographically disposed but with limited annotation from the map and that with all the flight progress data but little sense of positional relationship from the real or preferably electronically simulated flight strips.

The use of such information sources alone has been hampered both by technological limitations in displaying systems and user difficulties that are exacerbated by the use of such sources of display in combination.

In operation, the controller, unless dealing with a particular aircraft, continually scans the radar map and/or flight progress strips and clock to determine when the data displayed by them require the controller to initiate an action such as order a change of flight parameters or hand off the aircraft to another control region.

Where there is a lot of data displayed, due to many aircraft in the region to be controlled, the stress of dealing with the disparate, but potentially interrelated, aircraft is compounded by the correspondingly larger area of display

occupied by the flight progress data displayed, often forming a field of view larger than conveniently dealt with by the controller without excessive eye and head movements that are themselves fatiguing and contributary to the stress.

It is believed that the traditionally laid out controller stations are unergonomic and tiring on the controller largely because of this wide field of view required to display the information in legible form, but this, in effect the ratio of overall display size to viewing distance, cannot readily be eased by simply optimising this ratio because of constraints on one factor or the other.

With printed or electronic flight progress strips amended by annotation on the display surface the overall display size is determined by the number of strips required to control the aircraft of interest to the controller, the dimensions of the strips to permit annotation (particularly when the hand-written annotation represents a direct input to the computer that requires recognition decoding) and the presentation of a radar map on a separate display medium whilst the viewing distance is dictated by the need for manual annotation of the strips.

With electronic flight strips the viewing distance may be increased by using an alternative, indirect, form of input device that does not require contact with the display surface but the relationship between flight progress strip character size and viewing distance still demands an overall display size that is unergonomic for controlling the number of aircraft expected at peak times at many regions in terms of the amount of movement required by the controller in scanning and manipulating the displayed information. Because of the resolution of most forms of electronically driven display devices it would not be expected to improve upon the overall display size demanded by printed flight strips but the availability of high definition raster scanned CRT's goes some way towards achieving comparable dimensions whilst retaining the benefit of an interactive system as smaller character sizes are permissible without loss of legibility for viewing at somewhat closer distances.

However the fundamental relationships between legibile character size, viewing distance and number of simulated flight progress strips to be monitored still leaves a requirement for a display screen that is larger than commercially available, at least at reasonable cost, which even then does not satisfactorily avoid the problems of unergonomically excessive area to be scanned by the controller.

It is an object of the present invention to provide an air traffic control system including at least one controller station that is more ergonomic in operation hitherto.

According to the present invention an air traffic control system comprises a secondary surveillance radar system including a plurality of radio beacons defining reporting waypoints through the controlled airspace of the system, flight planning means operable to accept input of advance flight data for each aircraft to use system airspace to define a flight plan for the aircraft, central processing means responsive to the flight plan data and radar system data to define a set of flight progress data describing the flight of each aircraft through the system airspace, at least one controller station, associated with a region of system airspace defined by the disposition of a plurality of said radar beacon reporting waypoints, comprising data display means, fed by the central processing means, operable to display data associated with the region and controller input means responsive to an input action by a controller identifying an aircraft having displayed flight progress data to access, and permit controller input to change, any displayed flight progress data stored in the processing means associated with the aircraft, abridging means operable to display for each aircraft a subset of flight progress data stored in the central processing means including the aircraft identification, cleared flight level, next reporting waypoint and estimated time to the waypoint, primary sorting means operable to form for each control station a pending group of the subsets of flight progress data for aircraft whose next reporting waypoints are in the airspace of the controller station pending acceptance of the aircraft by input action of

the controller, secondary sorting means responsive to an input action by the controller identifying any aircraft having a data subset in the pending group, and representative of acceptance of the aircraft to the controllers region, to group the subset with others accepted by the controller and associated with the same next reporting waypoint as a waypoint group, subset display control means operable to cause display at the control station of subsets of the pending group and subsets of the waypoint groups each in one of a group of display regions individually associated with an individual reporting waypoint of the controller region, and expansion means responsive to the identification of an aircraft by the controller input means to display the full set of flight progress data of the identified aircraft.

An embodiment of the invention will now be described by way of example with reference to the accompanying drawings in which:-

Figure 1 is a plan view of an airspace controlled by an air traffic control system illustrating a plurality of geographically disposed reporting waypoints and air corridors in which they lie and boundaries which define regions controlled by individual control stations,

Figure 2 is a schematic block diagram of an air traffic control system according to the present invention, and

Figure 3 is an enlarged view of the display means at a controller station showing the ergonomic display of displayable data,

Referring to Figure 1 this shows a map of a country in the airspace above which are defined notional air corridors 10_1, 10_2 along which aircraft fly to traverse the airspace or arrive at or depart from airports in the country. The airspace, which is limited and defined also by altitude or aircraft flight levels, is divided into a number of regions 11, 11', ... each under the responsibility of a controller with whom the aircraft are in contact whilst in that region and the air corridors are delineated by reporting waypoints, such as 12_1, 12_2, 12_3, $12'_1$ ..., provided by radio beacons at

which the aircraft in the corridors report to the controller for the region who can monitor the progress and issue instructions to maintain separation of the aircraft.

Referring now to Figure 2 the air traffic control system 15 comprises a secondary surveillance radar (SSR) system 16, of form known per se, comprising a radar tranmitting and receiving station 17 and a plurality of radio beacons 28. The beacons and the radar station, which interrogates both the beacons and any aircraft in the airspace, are connected individually to radar system processing means 19.

Each aircraft may carry a transponder, effectively as part of the SSR system, such that the radar returns, as well as providing signals for determining aircraft azimuth bearing and range in a manner similar to primary surveillance radar, include response transmissions from the aircraft giving its identification code, or callsign, and altitude, known also as mode C.

The SSR system 21 is well known per se and will not be described further here but clearly enables the provision of a radar 'map' displaying both the positional relationship of radio beacons and aircraft.

The radio beacon emissions are furthermore received by the aircraft and provide means for determining its position in relation to the beacons, in particular its distance from, or time of passing, the beacon representing its next reporting waypoint.

The air traffic control system 15 also includes central processing means 20, to which the radar system processing means is connected to supply data relating aircraft position with respect to the beacons, and possibly its altitude, and flight planning means 25 which comprises means 26 to effect a data input to the central processing means 24 which together comprise an arrangement known generally hitherto for submitting planned flight data and issuing such data in the forms of printed flight progress strips for each aircraft giving its identity, including not only the call sign by which it is addressed by air traffic controllers but radar transponder fixed response details and aircraft type, its cleared flight altitude level or levels, the

sequence of reporting waypoints encountered with time estimates for transit between and any other special details relating to the aircraft.

Such generally known flight planning means is also known in specific form adapted to produce such flight progress strips as electronic images on display means, such as a CRT, at a controller station also equipped with data input means that renders the system interactive and permits updating of the flight progress data and display of the current flight progress data to any relevant one of a plurality of controller stations.

The system 15 has at least one, but preferably a plurality of, controller stations 27, 27', 27" each assigned to a region of the system airspace, such as 11 in Figure 1, defined by the disposition of the radar beacons 22 that form the reporting waypoints 12_1 etc. and at each station a controller is assigned to monitor and control the flow of air traffic through the region whilst all controllers have access to, and receive data from, the central processing means 20.

One controller station 27 is shown in some detail as comprising data display means 28 fed by the central processing means and able to display air traffic data associated with the region controlled by the station and controller input means 29 which responds to action by the controller to input data, which may be instructions to operate on existing data, to the central processing means 24.

The controller input means 29 may be a direct input device such as a keyboard or a form of display pointing device which works in association with displayed information to input some function of that information, such as an instruction to reorganise or accept new data into that inforation set.

A display pointing device may be a direct input pointing device, such as a light pen or touch-sensitive display screen, which reacts to the region of the display approached to relate input to the displayed information associated with that approached region or an indirect input pointing device, such as a mouse, tracker ball, joystick or touch tablet, which causes a cursor to appear at an appropriate region of the display screen

superimposed upon the displayed information and responds to an input signal for the processing means to relate input to the displayed information associated with the region of display in the vicinity of the cursor, the extent of the region being definable.

An indirect input pointing device may be preferred as not limiting the separation of controller and display and giving greater freedom in choosing the extent of display region considered addressed by a particular cursor position.

In accordance with the present invention the display means 28 comprises a high definition raster scanned CRT display 30 and a display formatting means 31, including a frame store, into which data from the central processing means 24 is assembled for display. The controller input means 29 has a connection directly to the display formatting means which determines the position of the cursor (or direct input) in relation to the display screen and data associated with that region of the display, furthermore responding to an execute signal from the input means to 'capture' that data, that is, make it available as input to the central processing means 24.

Also in accordance with the present invention the central processing means 24 has provided by suitable hardware or software means, abridging means 32 which for each aircraft derives from the set of flight progress data a subset of flight progress data that includes the aircraft identification, cleared flight level, next reporting waypoint and estimated time to the next reporting waypoint. The subset may contain additional information such as aircraft heading if it is not travelling along a designated air corridor or a flag that indicates it has acknowledged a cleared fight level but has not been confirmed as arrived at it.

The central processing means also has provided by suitable hardware or software sorting means 33 which organises the subsets of data into groups. Primary sorting means 33_1 forms a pending group, that is, a group of flight progress data subsets for aircraft whose next reporting waypoints are in the airspace of the controller station, say 27, but which have not

yet been acknowledged as having been received, or 'accepted' by an input action on the part of the controller. Such subsets are formed when an aircraft having data in the central processing means enters the region from an adjacent one, which may include an airport Terminal Control Area such as 11"" upon take off of a new flight, that is, when the cleared flight level is within the altitude window of the controlled region and the next reporting waypoint is in it.

Secondary sorting means 33_2 responds to an input action of the controller confirming acceptance of one of the aircraft having data in the pending group and forms a plurality of groups of said data subsets by next reporting waypoint, conveniently called waypoint groups of subsets. When, by controller input action upon aircraft report or possibly by automatic determination by the SSR system, any aircraft of a group associated with a particular next waypoint is confirmed as at or past that waypoint, the next reporting waypoint is changed in the flight progress data, including the subset, and the subset is now moved to the group associated with the 'new' next reporting waypoint.

The sorting means 33 is associated with subset display control means 34 which causes display at the display means 30 of the subsets of the pending and waypoint groups.

Referring to Figure 3, which illustrates a display formed on the high definition CRT 30, the subset groups formed by the sorting means are displayed each in one of a group of display regions 35, 36 etc. the waypoint groups being displayed at 35-39, under headings or banners 41 identifying the individual reporting waypoints 12_1-12_5 of the controller region 11, as a line 42 of alphanumeric characters preferably within a border 43 to create an abbreviated form of the familiar controller flight progress strip 46. The abbreviated electronic flight progress strips 44 are also conveniently grouped in relation to each banner 41 as a vertical stack and the banner-headed waypoint groups are preferably disposed on the display means relative to each other in at least approximate correspondence to the geographical disposition of the reporting

waypoint beacons in the region of airspace controlled by the station.

The subset data which is to form the display and the instructions which govern the relative dispositions on the display are supplied by the central processing means to the formatting means 31 to produce the display in suitable raster form.

It will be seen that by displaying for each aircraft in, and pending acceptance to, the region the minimal subset of flight progress data considered necessary to monitor its progress to the point of communicating with it, the data for a large number of aircraft can be organised to occupy a much smaller portion of total display screen area than hitherto when attempting to display for each aircraft all the flight progress data normally found on a flight progess strip.

In particular, the pending group which includes data for aircraft headed to different reporting waypoints requires display of the reporting waypoint code, whereas the subsets of accepted aircraft, by organising into waypoint groups, can be displayed under the banner for the waypoint will this omitted from the subset data displayed, further economising on display area occupied.

However the full flight progress data is not superfluous to the detailed progress of any aircraft. The system is provided with what is conveniently called expansion means 45 that responds to identification of any aircraft having displayed data by action at the controller input means to display the full set of flight progress data for the identified aircraft, such as in the form of a electronic full flight strip 46 having both the alphanumeric progress data 47, external and internal boundaries 48 and similar in total data contents to the traditional paper or electronic flight strip.

Considering again the preferred form of controller input means 29 as an indirect input point device, a cursor 50 is superimposed upon the display screen and the input means is arranged such that the region of display addressed, or 'hooked', by the cursor when it enters any of the bounded simulated strips

44 is the whole of that bounded region and when the region is 'captured' by executing the input action, the whole of the data associated with that region is considered as 'input' to the central processing means and the aircraft identification singled out, thereby permitting the central processing means to make available all the flight progress data associated with that aircraft for amendment by subsequent input. The aircraft identified by way of moving the cursor 50 onto one of the abbreviated strips 44 of the subset groups and selecting it automatically causes the expansion means to produce also the full strip 46 for that aircraft identified by the central processing means from the subset.

The use of an indirect input pointing device and displayed data subsets thus provides a convenient and ergonomic way of monitoring the aircraft in the region and accessing the full data of any particular aircraft by addressing its displayed image.

Clearly there are many controller activities which require flight progress data to be amended or added for reported actions of aircraft to be confirmed or for aircraft to be handed off to other control regions and related to the aircraft concerned.

The display means 28 may also be arranged to display a menu 51, possibly extending to several 'pages', conveniently in the form of bounded display regions 52_1, 52_2 etc. which can be hooked by the cursor in the same manner as the subset regions 40, and conveniently to which menu the cursor is directed as a result of capturing or otherwise addressing one of the subset regions.

Thus in operation when a controller activity or input relating to a particular aircraft is required the controller hooks the appropriate subset by means of the cursor to capture the flight progress data for that aircraft and the cursor automatically moves to the menu region whereby selected operations may be confirmed by means of an input to the processor, such as hand-off to another controller station, in whose pending group it will appear, and possibly by identifying

that station on a further menu page, a reported reaching of a new cleared flight level or a report of passages of a waypoint, and/or new data may be entered by a menu identifying the data to be changed or added and a menu of data characters for entry. The extent to which the displayed flight plan data is modified is open to choice and may permit a complete change of course data if an aircraft is re-routed.

The cursor stays in the menu region until the menu, and the input options it offers, is deselected, conveniently by an 'escape' region, returning the cursor to the part of the display where a different aircraft flight data subset may be hooked.

The instruction and/or data input is preferably echoed in a display line 53_1. Similarly the hooking of any particular display region may be echoed by a change in display appearance, such as a colour change, prior to, and to obviate erroneous, capture.

It will be appreciated that such input techniques are not dependent upon the precise form of pointing device and may be used in combination with a keyboard for direct entry of aircraft identification and subsequent data.

The interactive nature of the system, the use of sorted flight progress data subsets and the ability to address the data of a particular aircraft rapidly enables several control functions to be performed with great ease.

For example, each aircraft normally reports when it passes the next waypoint on its route and both the passage and the time are recorded by the controller. In the system described herein the controller responds to such a report by identifying the aircraft by using capture of the subset display for that aircraft, readily recognised from those grouped in relation to the particular reporting waypoint and its position in the group, as an input action and then moving the cursor to the appropriate menu function that relates to acceptance of waypoint-passing report. Capture of the menu function as a second input action not only permits the secondary sorting means to move the data subset of the aircraft to a new waypoint group but also records the time of input action from a real time clock

of the system for updating the flight progress data for the aircraft. The clock produces an indication of the current time at 53_2. If the SSR system and central processing means 20 is able to determine automatically by primary radar returns or transponder data that a waypoint has been passed or the identity of the next waypoint, this may be caused to update the display automatically repositioning the abbreviated flight strip 44 in accordance with the current next waypoint without action on the part of the controller.

As another example, the subset may include a flight course heading and provision made to display this but with the display suppressed when the heading is within the appropriate air corridor, thereby attracting the controllers attention only when an unusual heading is in operation or if any aircraft strays from its designated corridor.

As yet another example, when the aircraft requests, or is instructed, to change flight level a new cleared level is entered by the controller, having first accessed the appropriate data for the aircraft by way of the displayed set, and in addition to the new cleared flight level a flag appears in and is displayed with the data subset, for instance as a directional arrow shown at 54. When the aircraft reports assumption of the new flight level the controller again accesses the aircraft by way of its displayed data subset and acknowledges the report by pointing with the cursor to the appropriate menu region, at which point the new flight level is acknowledged to the system and the additional flag removed from the subset and the symbol from the display. Alternatively if the SSR system provides a mode C indication of aircraft actual height, the central processor may compare this with the new cleared level and upon assumption thereof cause the additional flag to be removed from the subset and the symbol from the display.

It will be appreciated that the techniques employed to display and vary stored data interactively by pointing at addressing regions of a raster scanned CRT occupied by displayed variable (aircraft data subset) legends and fixed (menu) legends

are well known per se and require description in no further detail.

In keeping with the objectives of minimising the extent of controller eye motion in scanning all the information the groups of data subsets and input action menu are confined to part only of the display screen and at the remaining region is displayed a synthetic radar map 55 showing the geographical disposition of the reporting waypoints 12_1-12_5 formed by radio beacons 18 and aircraft as points 56, the radar map preferably having superimposed thereon the boundaries of the region 11 and air corridors 10_1, 10_2 and legends or tags 57 identifying the aircraft at the marked position by a further subset of flight progress data including the aircraft callsign, flight level and, if appropriate the symbol employed in the first subset as indicating the aircraft is in the act of climbing or descending to a new cleared flight level.

The display of the radar map 55 with the individual aircraft as points 56 occupying regions of the same display device as the groups of alphanumeric subsets 35-40 means that the input pointing device is able to provide an input action identifying an aircraft by being positioned at the marked position of the aircraft on the map display, which may include that occupied by the tag data subset, as well as at the position of the display screen occupied by the bounded data subset (44) and the techniques of echoing hooking of the aircraft by change in the display, such as change in the colour of the associated data, may be employed for the map information, including any tag legends, as for the group subset and both may be indicated or echoed as hooked irrespective of which is pointed at.

It is well accepted that in air traffic control systems the links between the locations of radio beacons 18 and the radar processor 19 are vulnerable and that occasionally the system is unable to generate or update a radar map, so that the relative disposition of the aircraft has to be assessed by the controller from the flight progress strips alone.

In the system of the present invention by organising the displayed waypoint groups into an approximate correspondence

with the reporting waypoint beacons of the controlled region, permitted by the use of abbreviated data subsets, it is easier and less stressful for the controller to follow aircraft in a similar part of the region by their being sorted into groups headed towards the same next reporting waypoint, and by following thus from group to group.

It will be appreciated that the inclusion of the radar map 59 on the same display screen as the subset groups is convenient and simplifies input actions but is not essential, should a large number of aircraft to be controlled demand an increase in display area.

However, the use of a high definition raster scanned CRT permits flexibility in varying the dimensions of the various parts of the display in accordance with the amount of information, to be displayed, such as reducing character size, although in practice it is preferred to maintain the size of the subset characters which are most frequently scanned and interpreted in detail whilst reducing the size of the radar map display which tends to be glanced at as a means of drawing attention to aircraft whose data subsets should be viewed.

Alternatively, and particularly as reduction in map dimensions may make the legends tagging aircraft difficult or confusing to read if they are reduced in size or overlap others, despite an ability to 'rotate' the displayed position of tags about the aircraft point to avoid this, and the number of data subsets displayed as simulated abbreviated strips 44 may be limited in number, accommodating larger numbers of subsets in the waypoint groups by restricting the numbers of subsets in the pending group and if necessary redisposing the waypoint groups.

For instance, the waypoint group banners 41 may initially be set out as illustrated in the three columns corresponding to the reporting waypoint beacons and permitting equal numbers of subsets in the groups, with the pending group 40 occupying a fourth column.

If any of the waypoint groups 35-39 becomes so large as to abut a lower one in the same column that lower group moves down the column to maintain separation between the groups, with

any subsets of the lower group that will not fit above the region allocated for the full strip 46 being caused to wrap around onto the next column to the right, lowering the banner 41 and subsets of groups in that column and causing them, if necessary, to wrap around into the next column.

This action may result in one of the waypoint groups, for example waypoint 12_1 or ISS as shown, wrapping around into the region normally occupied by the pending group 40 which is then also depressed with the effect of reducing the number of pending subsets that can be displayed. However, by organising the primary sorting means to sort aircraft in terms of the shortest estimated time to any one of the reporting waypoints those pending aircraft which need to be accepted quickly by the controller in order to enter waypoint groups will be displayed at the expense of those which still have a long approach time to the controlled region. Aircraft of the pending group whose subsets are not displayed through lack of screen space may nevertheless appear on the radar map and be accessed by pointing at the map position.

As an extension of this any aircraft displayed on the radar map, even if not on the pending or accepted lists, may be accessed by the controller as may any aircraft not displayed at all be accessed by keyboard input, such access to unaccepted aircraft being limited to viewing the full flight strip data without opportunity to amend to safeguard against amendments without full cognisence of the surrounding aircraft and potentially conflicting of the correct controllers aims. Overriding control may however be made available to suitably authorised supervisory controllers.

If the pending groups actually contains more subsets than are displayed the input means may be arranged to permit the complete group to be scrolled through or allocated time on the display or for the controller to respond to verbal communication from the aircraft to call up display of the pending subset for any particular aircraft not displayed by way of inputting the identification (callsign) of the aircraft or accept it to the controller's region by keyboard or accessing alphanumeric menu

without displaying its pending subset, in addition to access via a radar map.

It will be appreciated that by use of a raster scanned CRT provides a stable display making full use of colour to ease operator discrimination of data and high definition raster scanned CRT's are now available which permit sufficient number of lines of readily legible alphanumeric characters to permit an adequate number of subsets and a radar map with legible legends to be assembled on the same screen within a field of view of the controller that is ergonomic for prolonged operation that involves scanning, addressing and amending the alphanumeric information.

It will be appreciated that the above described techniques may be applied to display devices, such as conventional CRT's or matrix addressed devices, having lower resolution by having a larger display area viewed from greater distance. This may then limit the choice of input pointing device that can be used and require a display size or controller station environment to permit its viewing which is technically or economically inferior to a high definition raster scanned CRT but still an improvement upon the overall display size and viewing distance hitherto required when displaying full flight progress data for many aircraft.

Claims:

1. An air traffic control system comprising

i) a secondary surveillance radar system including a plurality of radio beacons defining reporting waypoints through the controlled airspace of the system,

ii) flight planning means operable to accept input of advance flight data for each aircraft to use system airspace to define a flight plan for the aircraft,

iii) central processing means responsive to the flight plan data and radar system data to define set of flight progress data describing the flight of each aircraft through the system airspace,

iv) at least one controller station, associated with a region of system airspace defined by the disposition of a plurality of said radar beacon reporting waypoints, comprising (a) data display means, fed by the central processing means, operable to display data associated with the region and (b) controller input means responsive to an input action by a controller identifying an aircraft having displayed flight progress data to access, and permit controller input to change, any displayed flight progress data stored in the processing means associated with the aircraft,

v) abridging means operable to derive for each aircraft a subset of flight progress data including the aircraft identification, cleared flight level, next reporting waypoint and estimated time to the waypoint,

vi) primary sorting means operable to form for each control station a pending group of the subsets of flight progress data for aircraft whose next reporting waypoints are in the airspace of the controller station pending acceptance of the aircraft by input action of the controller,

vii) secondary sorting means responsive to an input action by the controller identifying any aircraft having a data subset in the pending group, and representative of acceptance of the aircraft to the controllers region, to group the subset with others accepted by the controller and associated with the same next reporting waypoint as a waypoint group,

viii) subset display control means operable to cause display at the control station of subsets of the pending group and subsets of the waypoint groups each in one of a group of display regions individually associated with an individual reporting waypoint of the controller region, and

ix) expansion means responsive to the identification of an aircraft by the controller input means to display the full set of flight progress data of the identified aircraft.

2. An air traffic control system as claimed in claim 1 in which the subset display means is operable to cause each subset of flight progress data to be displayed as a line of alphanumeric characters within a border to simulate an abbreviated form of controller flight strip and the groups of subsets to displayed as a vertical stack of simulated abbreviated flight strips separated from those of other displayed groups.

3. An air traffic control system as claimed in claim 2 in which the subset display control means is operable to cause the waypoint groups of data subsets to be disposed on the display means relative to each other in at least approximate correspondence to the geographical disposition of the waypoint beacons in the airspace region controlled by the station.

4. . An air traffic control system as claimed in any one of claims 1 to 3 in which each subset is organised to include a data flag, indicative of a new cleared flight level agreed between controller and aircraft, and displayable as a symbol between input of the new cleared level data and input of reported assumption of the level by the controller.

5. An air traffic control system as claimed in any one of claims 1 to 4 in which each subset is organised to include the aircraft heading and the subset display control means is arranged to suppress display of the heading if it falls within that corresponding to motion along a predefined air corridor.

6. An air traffic control system as claimed in any one of the preceding claims in which the secondary sorting means is responsive to identification of an aircraft by input action from

the control station and inputting the time of passing the waypoint associated with the subset for the aircraft to redefine the subset in terms of the next waypoint recorded in the flight program data and the estimated time thereto.

7. An air traffic control system as claimed in any one of the preceding claims in which the controller input means includes a display pointing device operable to identify stored information displayed by its position in the display and is responsive to the identification of a region of the display associated with data of a displayed subset to permit such identification as an input action indicative of identifying the aircraft having the displayed subset.

8. An air traffic control system as claimed in claim 7 in which the display means includes a region having a displayable menu of input options representing operation and input data each assigned a region of the display when displayed and the controller input means is arranged to effect the operation or input data displayed by means of the display pointing means.

9. An air traffic control system as claimed in claim 7 or claim 8 in which central processing means includes a real time clock and is arranged to interpret a controller input action indicative of an operation in which the time effected is required by the flight progress data as completion at the real time of controller input action.

10. An air traffic control system as claimed in any one of the preceding claims in which the central processing means includes means to provide data to form at the dislay means of each control station a radar map including reporting waypoints associated with the control station and positions relative to the reporting waypoints of identified aircraft for which subsets of flight progress data are formed.

11. An air traffic control system as claimed in claim 10 when dependent on any one of claims 7 to 89in which the display pointing device is operable to identify any aircraft by way of the position of the aircraft on the map image.

12. An air traffic control system as claimed in claim 10 or claim 11 in which the radar map, groups of subsets and full

flight progress data for any identified aircraft are displayed on the same display device.

13. An air traffic control system substantially as herein described with reference to, and as shown in, the accompanying drawings.

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